Metals, Alloys, and Intermetallics

materials for today... and tomorrow

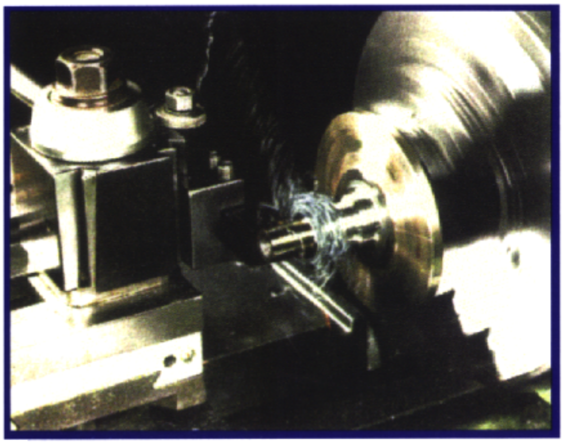
Even with increasing use of plastics and ceramics, metals and their alloys still make up most of the structural materials used today in cars, girders for buildings and bridges, wire, pipes, and a wide range of other commercial products. Metals, however, have limitations: some rust, some are heavy, and some weaken at high temperatures or in severe environments. Although we have thousands of years of experience with metals, the problems that remain are complex; but BES research is providing industry with the tools and new insights needed.

BES scientists have been involved in developing many new alloys, including a special class of materials called structural intermetallics, which have the unique property of becoming stronger as temperatures increase. Historically, however, intermetallics have had one major problem: they were very brittle, especially at room temperature. BES alloy science helped unlock the secret of making intermetallics ductile so they do not fail easily or catastrophically, and so they can be machined into needed shapes. Today, a number of commercial products are available and/or under development.

BES research also has developed new steels, improved aluminum alloys, magnet materials, and other alloys. As an outgrowth of surface science research, coatings and special surface-modification technologies are being used to enhance the wear and corrosion resistance of metals. In the environmental arena, BES is leading the way to develop improved and lead-free solders that are used extensively in manufacturing semiconductors.

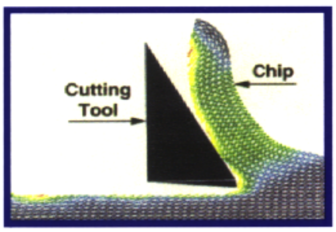
Modeling and first-principles alloy design are other areas in which basic science is making important contributions to aluminum and other metals processing. Industry is using BES computer codes that can predict the changes that metals undergo during fabrication to improve products and reduce costs.

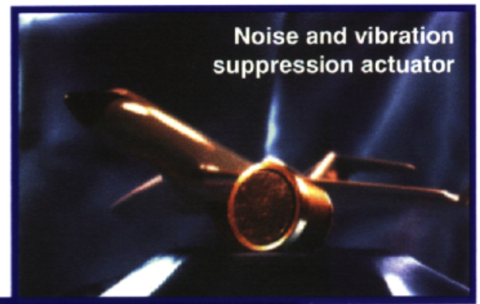
Intermetallic alloys, based on research done at Oak Ridge National Laboratory, are the subject of more than 10 licenses and a number of cooperative agreements with industry. Shown here are nickel aluminide furnace fixtures and dies that are commercialized or are under testing in an industrial setting. The trays (left) are greater than twenty times the size of the molds. Intermetallics are being used in high-temperature applications where they last five- to ten times longer than superalloys. Intermetallic research has evolved under an integrated basic and applied research effort funded by BES and DOE's Energy Efficiency and Fossil Energy programs.



Machining Metals

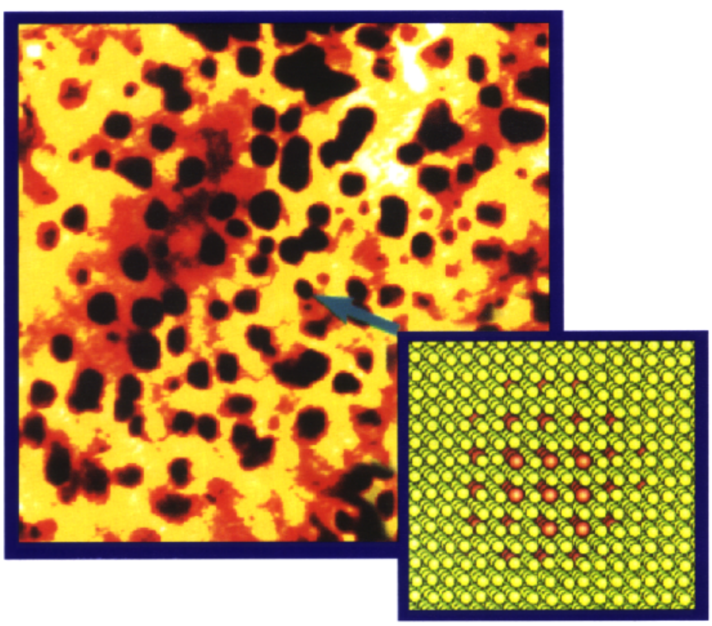
Using fundamental models that describe how metals deform, Los Alamos National Laboratory is collaborating with a major automobile manufacturer to improve the manufacturing process of metal cutting. Shown here is the computer model for forming metal chips with a cutting tool, along with a photograph of the actual process. As part of a collaborative relationship funded by DOE Defense Programs, the models developed by Los Alamos are being validated by comparing them with machining data generated in an industrial setting.





Shape Changers

Some commercial products, such as the ones shown above, use “Terfenol,” a material that changes shape when exposed to magnetic fields. When that happens, this material, developed by Ames Laboratory and the Naval Surface Warfare Center, undergoes dimensional changes that exceed those of other commercial magnetostrictive materials by a factor of 10. A new company, ETREMA Products, Inc., was established to commercialize products made from Terfenol; the company now employs more than 20 people.



Atomistic Simulations

Atomistic simulations, developed at Sandia National Laboratories to understand fundamental alloy properties, are being combined with Alcoa’s models for manufacturing aluminum. The aim is to obtain a code that will aid in developing new aluminum alloys and designing the processes to make these alloys. The figure combines experimental evidence of aluminum scandium precipitates (the micrograph) with calculations that predict the formation of spherical precipitates (the red circles are scandium atoms; the yellow are aluminum atoms).